Supplementary Materials

Multiphase Conduction and Piezoelectric Properties of 2D $(GA)_2PbI_4$ Ruddlesden-Popper Perovskite for Energy Harvesting Applications

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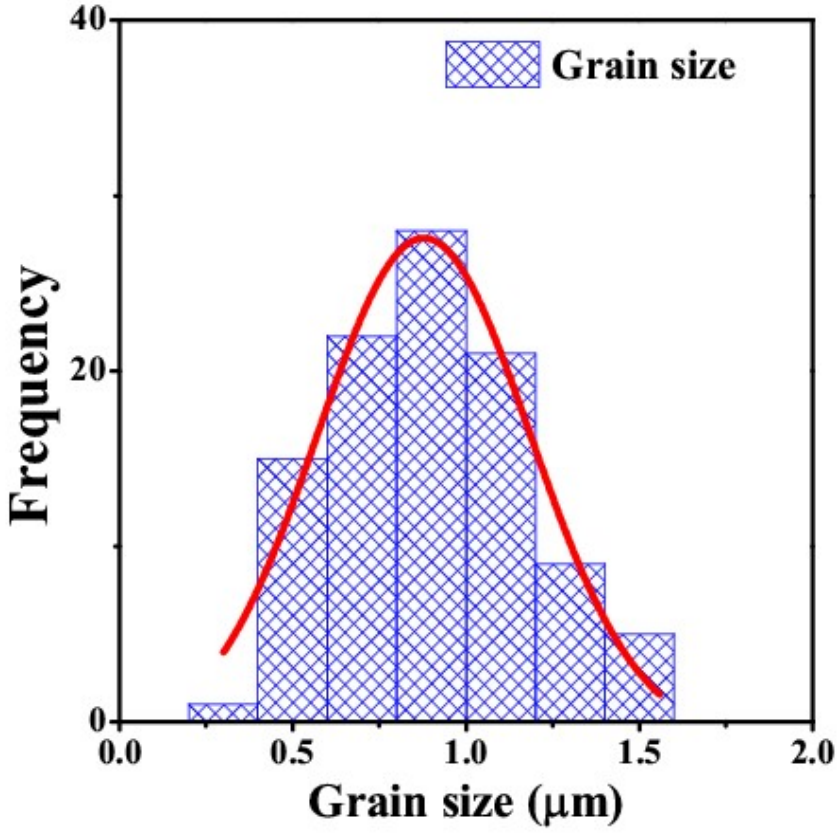

FIG. S1: *Histogram for the distribution obtained from SEM image of the $(GA)_2PbI_4$ perovskite material.*

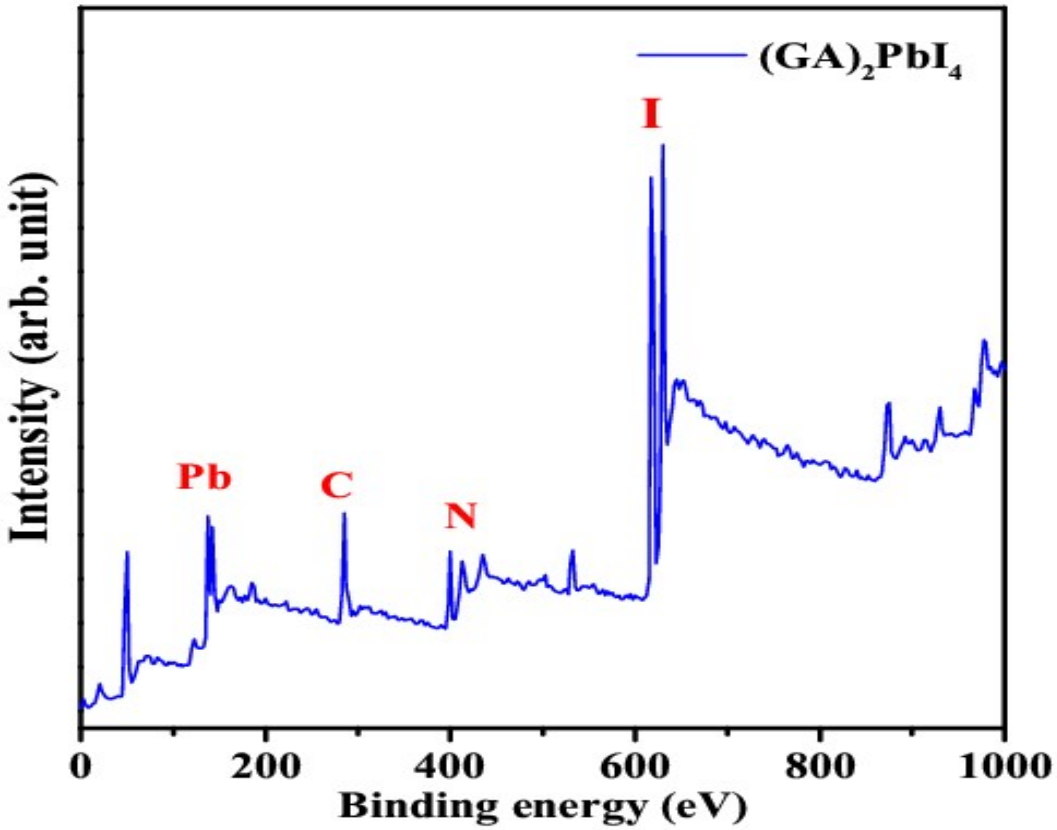

FIG. S2: *XPS survey scan of the $(GA)_2PbI_4$ perovskite material.*

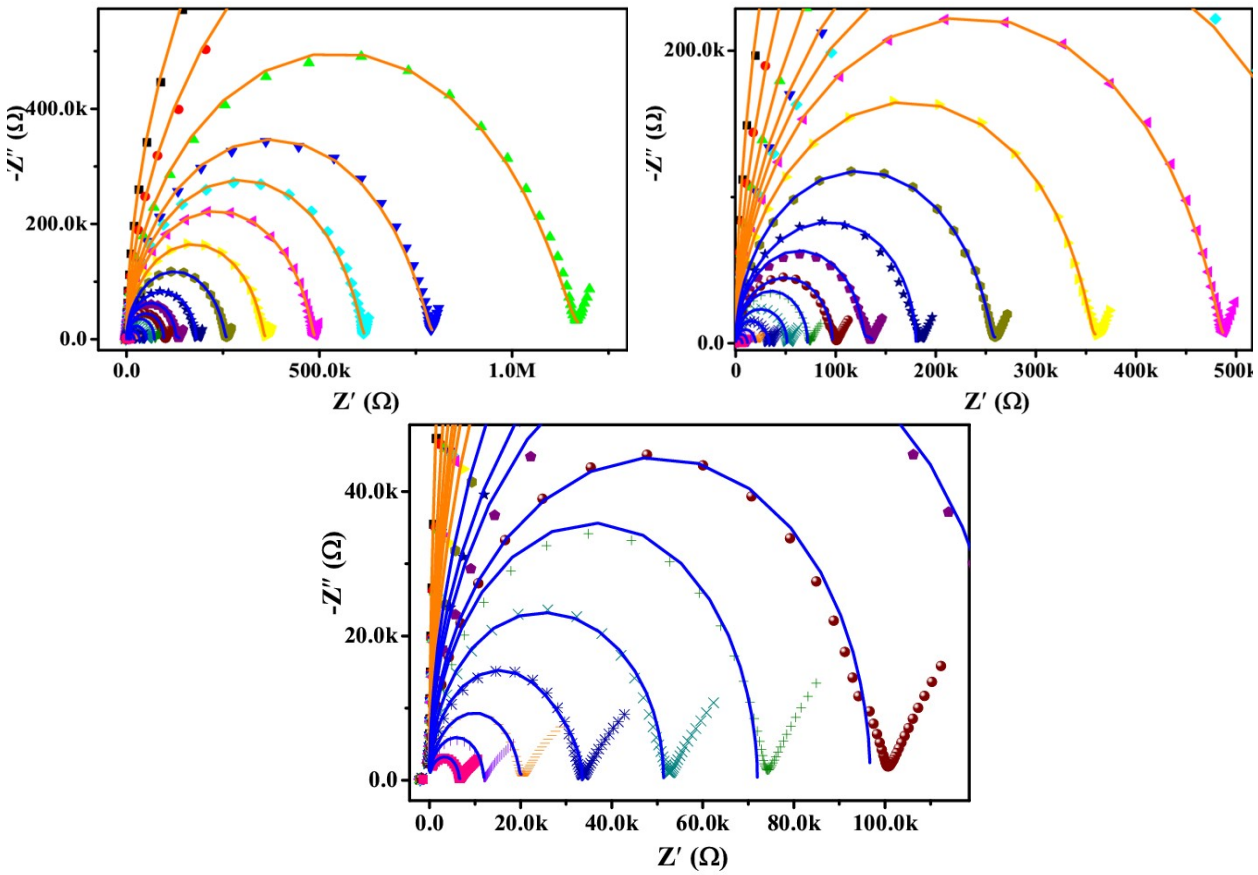

FIG. S3: Enlarge view of Nyquist plot at different regions.

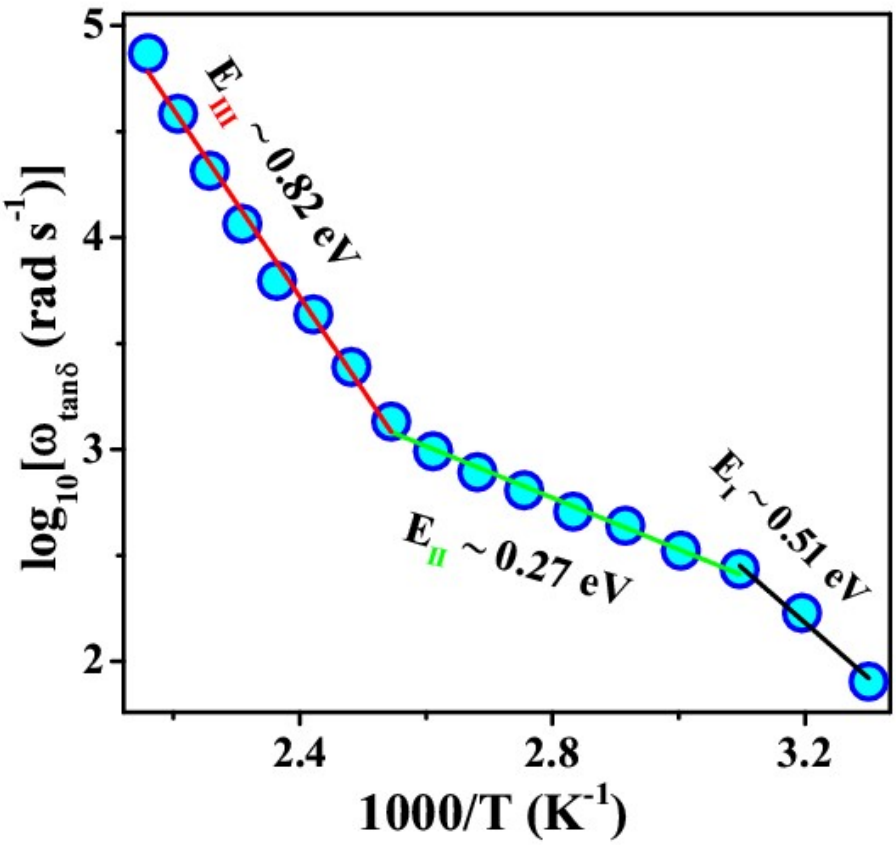

FIG. S4: Reciprocal temperature dependence of loss tangent peak frequency.

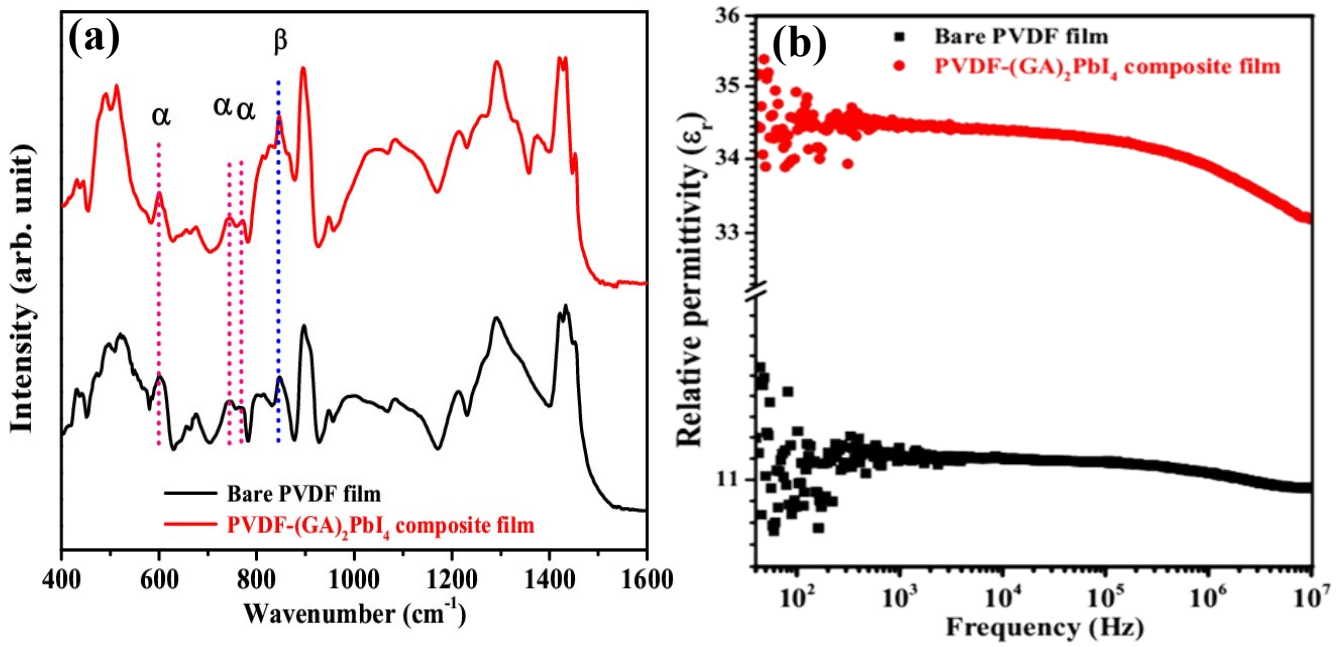

FIG. S5: (a)FTIR spectra and **(b)**Frequency dependence of relative permittivity of the synthesised films.

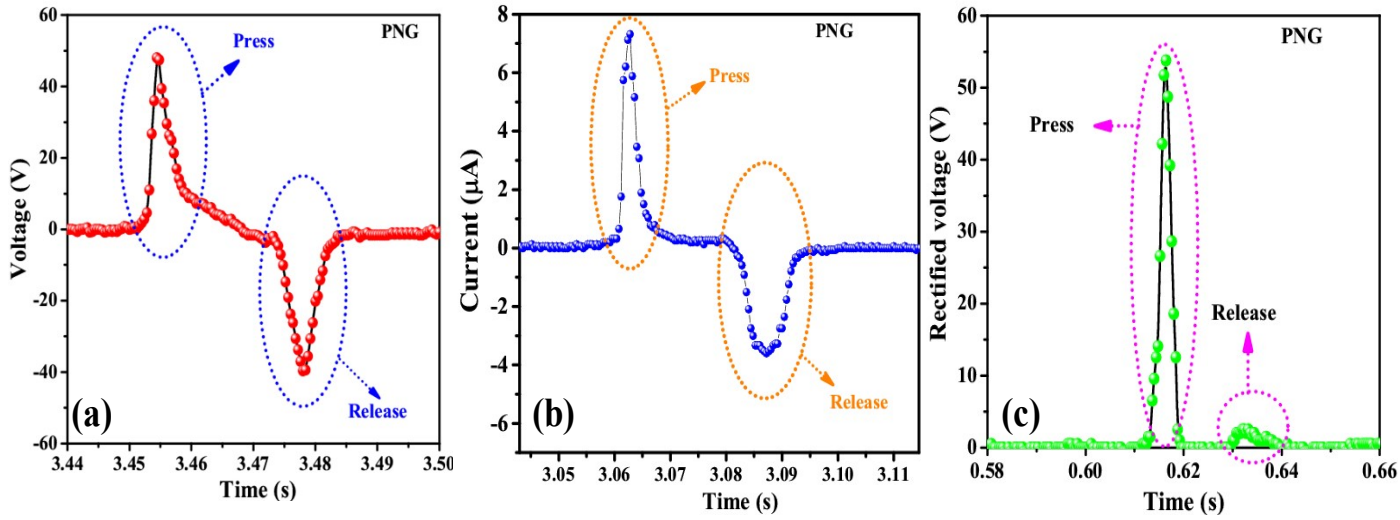

FIG. S6: The enlarged view of a single peak of the corresponding output **(a)** voltage, **(b)** current and **(c)**rectified voltage vs. time.

Tables S1: XPS fitting results of the GA_2PbI_4 perovskite.

Peak Name	Position (eV)	FWHM (eV)	Raw Area (a.u.)	Sensitivity factor (SF)	Atomic%	Calculated ratio	Theoretical ratio
C 1s	284.5	1.32004	3681.03	1	16.27	2.07	2
C 1s	285.3	2.47173	467.98				
C 1s	288.7	1.52742	879.61				
N 1s	399.7	1.39085	25317.42	1.8	45.51	5.79	6
Pb $4f_{7/2}$	137.9	1.23427	5897.67	4.2	7.86	1	1
Pb $4f_{5/2}$	142.7	1.27731	4305.69				
I $3d_{5/2}$	618.5	1.42635	42384.42	8	30.35	3.86	4
I $3d_{3/2}$	630.04	1.44634	32650.35				

Formula:

$$Atomic\%_i = \frac{\frac{A_i}{SF_i}}{\sum \frac{A_i}{SF_i}} \times 100$$

where A_i = rawpeak area for element i.

SF_i = sensitivity factor for element i

Table S2: Fitting parameters obtained from real ($\sigma'(\omega)$) and imaginary ($\sigma''(\omega)$) parts of the conductivity spectra.

T (K)	σ_{dc} (S cm^{-1}) Error <1 %	ω_H (rad s^{-1}) Error <2 %	n Error <2 %	C_{dl} (F) Error < 5 %	τ_∞ (s^{-1}) Error <2 %	α Error < 4 %	m Error < 5 %	C_b (F) Error < 5 %
413	9.44×10^{-6}	1.06×10^{-8}	0.173	8.66×10^{-8}	5.91×10^{-6}	0.51	0.955	3.62×10^{-12}
423	1.33×10^{-5}	1.38×10^{-8}	0.164	1.26×10^{-7}	4.53×10^{-6}	0.46	0.954	2.57×10^{-12}
433	2.09×10^{-5}	2.017×10^{-8}	0.143	2.38×10^{-7}	3.11×10^{-6}	0.42	0.951	1.11×10^{-12}
443	3.46×10^{-5}	2.84×10^{-8}	0.131	1.71×10^{-7}	2.21×10^{-6}	0.39	0.948	8.61×10^{-12}
453	5.81×10^{-5}	4.03×10^{-8}	0.119	7.88×10^{-7}	1.56×10^{-6}	0.37	0.946	6.42×10^{-11}
463	1.06×10^{-4}	7.20×10^{-8}	0.122	2.55×10^{-6}	8.72×10^{-7}	0.36	0.945	4.84×10^{-11}

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